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IMPROVED RESONANCE SECURITY TAG AND METHOD OF PRODUCING  
SUCH A TAG

5 TECHNICAL FIELD

The present invention relates to a resonance security tag of the kind set forth in the preamble of claim 1 and a method of producing such a tag.

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BACKGROUND ART

Resonance security tags of this kind are e.g. known to be used in electronic article surveillance systems (EAS systems) in order to detect unauthorised removal of 15 articles from shops, stores or warehouses, and such resonance security tags are produced in large numbers on a dielectric foil material which is provided with conductive material layer patterns on both sides for forming an inductor and a capacitor forming a resonance circuit having a suitable resonance frequency and to be detected by means of suitable equipment positioned at the exit from the 20 premises. A resonance security tag of this kind is e.g. known from EP-0,285,559.

From JP 02-310696 it is known to cut the foil material along part of the circumference of the capacitor elements and fold the cut-free capacitor away from inside the inductor in order to leave this part free for the penetration of magnetic flux 25 through the inductor. However, experiments with this type of EAS-tag have shown a considerable variance in resonance frequency leading to reduced detection rates for such tags, and the present inventor has not seen any EAS-tags on the market which are produced in accordance with the method described in JP-02-310696.

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DISCLOSURE OF THE INVENTION

It is the object of the present invention to provide a resonance security tag of the kind referred to above, with which it is possible to improve the detection level, 35 maintain a precise resonance frequency, and at the same time possibly reducing or

maintaining the small size of the resonance security tag, and this object is achieved with a resonance security tag of the kind, which according to the present invention also comprises the features set forth in the characterising clause of claim 1. With this arrangement, the central part of the inductor is made free in order to allow 5 penetration of the magnetic flux through the inductor, whereby a higher detection rate is achieved, and the resonance frequency is maintained within narrow limits despite the folding operation due to the folding being performed to the side opposite the inductor pattern and presence of a shielding plate having a form and size corresponding to the form and size of the folded over capacitor plates improving the 10 frequency precision. Furthermore, the present invention relates to a method of producing such a tag.

Preferred embodiments of the resonance security tag in accordance with the present invention, the advantages of which will be evident from the following 15 description, are revealed in the sub-ordinate claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20 In the following detailed part of the present description, the invention will be explained in more detail with reference to the exemplary embodiments of a resonance security tag according to the invention shown in the drawings, in which

25 Fig. 1 schematically shows a tag positioned between a transmitter and a receiver at the exit from the store or like for detecting the presence of the tag at the exit,

Fig. 2 schematically shows an equivalent circuit diagram of the situation shown in Fig. 1 for explaining the parameters for improving the detection level,

Fig. 3 shows the conductive material layer pattern on a first side of the dielectric foil material of a resonance security tag in accordance with the present invention,

30 Fig. 4 shows the conductive material layer pattern on both sides of the dielectric foil material of a resonance security tag in accordance with the present invention,

Fig. 5 shows schematically in a perspective view a partially folded cut free capacitor of a resonance security tag in accordance with Figs. 3 and 4,

Fig. 6 shows the resonance security tag of Fig. 5 with the capacitor in a completely 35 folded position,

Fig. 7 schematically shows suggested instruments for performing the folding of the capacitor, and

Fig. 8 shows an alternative embodiment of the resonance security tag specially formed to be positioned on or inside a CD or DVD in accordance with a preferred embodiment of the present invention.

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#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 Referring to Figs. 1 and 2, the quality of a resonance security tag is discussed in the following. In Figs. 1 and 2, the tag 1 is positioned between a transmitter Tx in an electronic article surveillance system (EAS system), and a receiver Rx of said system. The transmitter transmits a radio frequency signal within a specific frequency range and whenever a tag with a resonance frequency within this range 15 is within the range of the transmitter and the receiver, the receiver will be able to detect the resonance frequency of the tag.

The detection rate or quality will be dependent on the Q-value of the resonance circuit and the physical size thereof. The formula

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$$Q = \frac{1}{r} \sqrt{\frac{L}{C}} \quad (1)$$

25 indicates that in order to obtain a high Q-value, it is desired to have a small value of r, a high value of L and a small value of C. A low value of r can be obtained by choosing a conductive material layer in the tag like e.g. silver and a high value of L can be obtained by providing several windings in the inductor and at the same time the capacitor can be chosen with a small capacitance C.

30 In practice, however, this is not how it is done due to the fact that the price of silver is too high and many windings of the inductor coil will demand more material and surface area for the tag, which would increase the price of the tag. Furthermore, if many small windings are chosen in order to save material costs for the conductive material layer, the value of r will increase. If a very small value of C of e.g. 10pF is

chosen, the resonance circuit will be sensitive to external influence such as stray capacities, which would change the resonance frequency.

As can be seen from the above, the design of the resonance circuit for an EAS system is a compromise between price and size, among other things. In the market there is a wish for a cheap tag as well as a small tag with a high rate of detection and Q-value. Accordingly, the resonance circuit normally comprises a dielectric foil material 2 of polypropylene or polyethylene provided with an electrically conductive material layer pattern on both sides, said conductive material usually being of aluminium.

The electrical equivalent diagram shown in Fig. 2 corresponds in principle to an EAS system and the mutual induction coefficients between the inductors L1, L2 and L3 are M12 and M23, respectively. The loss resistance in the resonance circuit in the tag is represented by r. The input resistance in the measuring circuit is represented by R. The measured voltage Vm represents the signal strength from the resonance security tag. The resonance circuit L2,r,C is positioned between the transmitter coil L1 and the receiver coil L3. The formula for the received signal strength Vm is

$$Vm = \omega_0 (M12 \cdot M23 / L1) \cdot \frac{V1}{r} \quad (2)$$

where  $\omega_0$  is equal to  $2 \pi f_0$  ( $f_0$  is the resonance frequency).

V1 is the voltage of the signal generator. When the coils L1, L2 and L3 (the cross-sections S1, S3 > S2), are arranged as shown, the mutual inductances are

$$M12 = K12 \sqrt{S2 L2} \text{ and } M23 = K23 \sqrt{S2 L2} \quad (3),$$

where K12 and K23 are constants. Using (2) and (3), we have:

$$Vm = K12 K23 (V1/L1) (\omega_0 L2/r) S2 = K \cdot Q \cdot S \quad (4)$$

K is a constant and Q is a measure for the quality of the resonance circuit

$$Q = \frac{1}{r} \sqrt{\frac{L}{C}}$$

S is the area surrounded by the magnetic flux. From the above it can be seen that V<sub>m</sub> is proportional to Q · S.

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In order to improve the tag, it is possible to increase Q or S or both.

The magnetic flux, which has to pass through the centre of the coil, is partially blocked by the capacitor in this position in a normal tag, referring to figures 3 and 4.

10 In order to increase the magnetic flux through the coil centre, it is desired to make the area of the capacitor as small as possible. As mentioned earlier, a certain minimum size of the capacitor is given, which leads to a restriction of the area in the centre of the coil which is free to allow the magnetic flux through the coil. The present invention removes the capacitor from the centre of the coil, whereby the 15 magnetic flux through the coil centre is increased and thus the detection rate for the EAS system is increased considerably.

20 In Fig. 3 is shown the conductive material layer pattern on the first side of the dielectric foil material 2, which is formed to provide an inductor 3, a first capacitor plate 4 connected to a first end of the inductor 3 and positioned inside the inductor 3, and a first connection element 5 connected to an opposite end of the inductor 3. In Fig. 4 the conductive material layer pattern on the second, opposite side of the dielectric foil material 2 is shown superposed on the pattern of Fig. 3. The 25 conductive material layer pattern on the second side of the dielectric foil material 2 is formed to provide a second capacitor plate 6 confronting the first capacitor plate 4 and a shielding plate 7 connected to the capacitor plate 6 and confronting the first connection element 5. The shielding plate 7 provides a patch of conductive material layer with a form and size corresponding to the form and size of the first and the second capacitor plate 4, 6.

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As shown schematically in Fig. 5, the capacitor plates 4, 6 have been cut 9 along part of the circumference of the first and second capacitor plates 4, 6 in order to fold the capacitor 4, 6 away from the central position inside the inductor 3. As shown in

Fig. 6, the cut-free capacitor 4, 6 is folded completely along the folding line 10 over to overlay the shielding plate 7.

- 5 Due to the fact that the capacitive coupling between the shielding plate 7 and the windings of the inductor 3 is constant, the folding of the capacitor 4, 6 to overlay the shielding plate 7 will result in a well defined controlled change in resonance frequency. The distance between the folded over capacitor 4, 6 and the shielding plate 7 is precisely fixed.
- 10 In order to compensate for possible mechanical tolerances in the folding of the capacitor, the shielding plate 7 is preferably provided with dimensions larger than the capacitor plates 4, 6 such that the folded over capacitor plates 4,6 will always be positioned inside the circumference of the shielding plate 7.
- 15 The electrical contact 8 between the first connection element 5 and the shielding plate 7 is preferably provided by irregular holes through the dielectric foil material 2 in the area of these elements 5, 7 before or after the folding of the capacitor plates 4, 6.
- 20 The cut 9 along part of the circumference of the first and second capacitor plates 4, 6 can be provided by mechanical means, by laser cutting, by heating the capacitor plates 4, 6, etc. The first part of the folding of the capacitor 4, 6 may be provided by mechanical means or by means of a jet of air, etc. An example of mechanical means for providing the folding of the capacitor 4, 6 is shown in Fig. 7, in which a folding tool 12 is positioned stationary over the foil material 2 and the foil material is moved towards this folding tool which folds the turned up capacitor 4, 6. In order to move the folded capacitor 4, 6 into intimate contact with the shielding plate 7 on the upper side of the tag, a further roller-formed tool 13 is positioned immediately after the folding tool 12 seen in the movement direction of the foil 2.
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- 30 The tag in accordance with the present invention is especially suited to be used as an EAS tag for a CD or DVD due to the fact that the hole in the middle can be positioned over the hole in the CD or DVD and the coil can be positioned so as to surround this hole in a position in which the CD or DVD has no metallic layer and thus allows the radio frequency field to pass through the area where the tag is
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positioned. This would not have been possible with a conventional tag due to the fact that a tag of this small size would not be detectable in an EAS system when the tag is produced in accordance with the conventional technique.

- 5 The tag in accordance with the present invention can, as shown in Fig. 8, be positioned centrally in a CD or DVD and may be integrated into the DVD between the layers of the DVD. In this situation the EAS tag cannot be removed without destroying the DVD.
- 10 The construction in accordance with the present invention has improved the specifications of the resonance circuit to an extent that allows a 10-20% reduction in the size of the resonance circuit. Due to the fact that material costs are the main costs in producing such tags, this reduction in size leads to a corresponding reduction in price for the tags.
- 15 Above, the invention has been described in connection with preferred embodiments thereof, however, many modifications may be envisaged by a person skilled in the art without departing from the scope of the following claims.